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A SHORT REMARK UPON W. H. LEWIS' "EXPERIMENTAL STUDIES ON THE DEVELOPMENT OF THE EYE IN AMPHIBIA."¹

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In the above-mentioned article, published in Volume III. of the *American Journal of Anatomy* (1904), W. H. Lewis has given us the results of a large number of ingenious experiments on frog-larvæ intended to determine the possible correlations between the development of the optic vesicle and that of the lens.

These experiments have, in the first place, offered a new and, as it seems to me, very convincing proof that there is indeed, as first maintained by Herbst and Spemann, a distinct correlation in the development of these two organs, namely in such a way "*that in normal development the lens is dependent for its origin on the contact influence or stimulus of the optic vesicle on the ectoderm.*"

Furthermore Lewis has, by transplanting the optic vesicle to another part of the larval body, demonstrated "*that the optic vesicle can stimulate a lens to form from various portions of the ectoderm and even from the ectoderm from the abdomen of another species of frog. . . .*" From this fact he has drawn the following conclusion: "There is no predetermined area of the ectoderm which must be stimulated in order that a lens may arise. On the contrary various portions of the skin when stimulated by the contact of the optic vesicle may and do give rise to a lens. Not only will a lens arise from various places on the skin as a result of the contact of the optic vesicle of the same animal, but the optic vesicle of one species may cause a lens to rise from the ectoderm of another species of frog." This latter result of Lewis' experi-

¹ Lewis, W. H., "Experimental studies on the development of the eye in Amphibia. I., On the origin of the lens, *Rana palustris*," *American Journ. of Anatomy*, III., 1904.

ments is of very great interest, in so far as it gives a new evidence of the *equipotential nature of the ectoderm elements* during a certain early period of development. However in further discussing his grafting-experiments and some other observations made in connection with them Lewis is also led to a criticism of a theory recently advocated by me, *namely that the lens has to be considered as a modified primitive sense organ*. As this criticism seems to be based upon a misconception of my article on this subject¹ I feel induced to write the following remarks in explanation.

Lewis says on page 535 of his paper: Schaper's theory "will not hold in view of the fact that the ectoderm, taken from over the abdomen of *R. sylvatica* and grafted on over the optic vesicle of *R. palustris* (see experiment XII., 51), did not possess at the time of operation the primitive sense organs and yet it gave rise to a lens. Again it seems unlikely that in several instances in which I have been able to bring about lens formation from a strange ectoderm that the optic vesicle should have in each case come in contact with one of these sense organs. And again in such experiments as IV., in which the optic vesicle has never been in contact with the ectoderm which normally gives rise to a lens there is no trace of a rudimentary lens such as Schaper pictures." From this remark it is obvious that Lewis holds, that according to my opinion the lens should arise in the course of *ontogenetic* development from a *performed* primitive sense organ of the skin.

In refutation of this, the following must be said. In the first place I have to state that nowhere in my above cited paper have I spoken of a *performed* primitive sense organ ("Sinnesknospe") as being the *ontogenetic* forerunner of a lens. What I have maintained is, that the structure which arises from the stimulated part of the ectoderm, to form the lens, shows in its development and its primitive histological features a striking resemblance to a primitive sense organ of the skin, and that this resemblance becomes still more striking when, as in my experiments, by atypical development the lens-anlage is retained within the ectoderm. The

¹ Schaper, A., "Ueber einige Fälle atypischer Linsenentwirkung unter abnormen Bedingungen. Ein Beitrag zur Phylogenie der Linse und zur Mechanik ihrer Entwicklung," *Anatom. Anzeiger*, XXIV., 1904.

evidence of this similitude is, as I think, fully demonstrated by the figures 9, 10 and 11 in my paper. Again, I have by no means considered the anlage of the lens within the ectoderm as a regular (*i. e.*, functional) sense organ ("Hautsinnesorgan."), as I have especially emphasized in the statement: Es "liegt uns selbstverständlich der Gedanke fern, unsere Lentoide functionell auf gleiche Stufe mit einer Sinnesknopse stellen zu wollen, . . .". I have always spoken of a *phylogenetic*, never of an ontogenetic deduction of the lens from a primitive sense organ. Finally I have expressed the opinion that the formation of "Sinnesknospen" is one of the most primitive tendencies of all ectodermal elements and that in any part of the ectoderm a bud-organ may arise under adequate stimulus. This being admitted, the conclusion seems to me justified that also the contact stimulus of the optic vesicle upon the ectoderm may awaken these most primitive properties of the ectodermal cells and result in the formation of a structure *morphologically* homologous with a primitive sense organ which in the course of phylogenetic development has gradually entered a new path of differentiation.

Taking all this into consideration, *the absence of preformed primitive sense organs in that part of the skin where the optic vesicle comes in contact with it and where in consequence the lens is formed is by no means an objection against my theory.* When my theory holds that the lens, from a morphological point of view, has to be considered as an ancient sense organ, which arose, it is true, *originally* from a primitive sense organ of the skin ("Placoden-Organ" of Kupffer), it does not of course imply the necessity that during *ontogenetic* development of later animal forms we should still be able to see the lens evolve *directly* from such an organ. Just as the mode of development of so many other organs, that of the lens also may have undergone, in the course of phylogenetic progress, considerable modifications until the original process of differentiation becomes more or less concealed. Now, if an organ, as in the case of the lens, *still* exhibits in its early ontogenetic features some distinct reminiscences of ancestral characteristics, we are all the more justified in drawing conclusions from such phenomenon in regard to the ancestry of the organ in question.

Hence, my observations upon the development of the amphibian lens (especially under abnormal conditions) having assured me of a close resemblance of this process to the differentiation of a primitive sense organ, I have advocated this fact as a new evidence, in addition to many others, of the originally sensory nature of the crystalline lens.